NCHRP 17-27: HSM Parts I and II Decision Rule

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NCHRP 17-27 – Parts I and II

- Brief Overview and Status of Project
- Decision Rule
- Future of the Knowledge base
- Potential Outcomes

Brief Overview

- NCHRP 17-27 will develop Parts I and II of HSM:
  - Chapter 2: Fundamentals
  - Chapter 3: Roadway Segments
  - Chapter 4: Intersections
  - Chapter 5: Interchanges
  - Chapter 6: Special Facilities
  - Chapter 7: Road Networks
- Provide best available safety-related knowledge

Project Status

- Critical review of published research (over 600 publications to date)
- Develop syntheses for each chapter based on Process developed
- Revise and expand annotated outline: Interim Report "Knowledge-base"
- Development of Chapter 2 (on-going)

Tasks Remaining

- With Panel Approval and Task Force Adoption
- Task 9: Develop Part II Prototype Chapter, Section 3.2
- Task 10: Comments from Panel and TF, Meet with Panel, Finalize Part II Prototype
- Task 11: Develop all chapters
- Task 12: Final Report
- Extension of 12 months from original schedule

Task Force Midyear Motions (T16)

"Inclusion of information in the knowledge section of the HSM, in accordance with decisions made in the past, will rely on **crash-based information** where possible and if crash-based information is not available, permit surrogate metrics if they have **proven connections** to crashes or crash severity. The knowledge section of the manual should also **identify what we do not know** rather than remain silent on a topic.

For questionable items, the **research subcommittee** or other review committee should make a recommendation."

Task Force Midyear Motions (T17)

"… The decision rule should be recommended by NCHRP 17-27 research team members. The research subcommittee will provide input to the NCHRP 17-27 research team and will review interim and final products. This process should be completed as quickly as possible to avoid delays in NCHRP 17-27. The contractor will consider at least the following factors for inclusion in the decision rule:

- **Stability over time** of information provided by HSM
- **Standard error**
- Probability of **AMF becoming > or = 1.0** due to future research
- **Expert opinion** based on a range of factors including sample size, study design, methodology, etc."

Task Force Guiding Principles

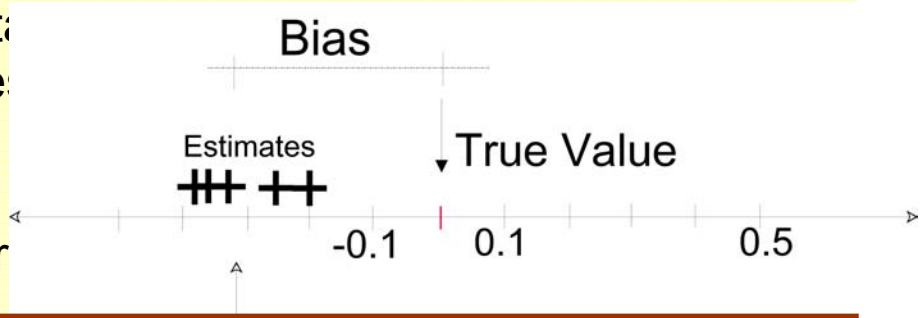
- Principle 6: "The HSM is focused on objective and quantitative measures of safety that have a known relationship with expected vehicle crash frequency and severity."
- Principle 10: "All quantitative methods, including accident modification factors (AMFs), that appear in the HSM meet established scientific criteria."

Process to Develop Knowledge base

- Process applied to estimate AMFs and std errors
- Knowledge base developed (March 2005)
- Need for decision rule to determine what to include in First Edition HSM

The Question:
How accurate must be the estimate of an AMF before it can go into the HSM?

A multiplier which tells me by what proportion **should I expect** accidents of a given severity to be changed if a certa
implemented in specified circumstance



Example:
Treatment: Convert two-way stop contr
Severity: All accidents
(If before 10 accidents expect 5.3 after)

To answer we must be clear about why exactly is it important that AMF estimates in the HSM be accurate?

Accuracy of an estimate tells how close it usually is to the true value. The customary measure of accuracy is the Standard Error (of the mean)

My Purpose:

1. To explain the main issues to allow formation of opinion.
2. To give my reasons for what is recommended.

Example Choice:

Treatments X and Y have equal costs.
Estimate of AMF for X =0.9 ± 0.2
Estimate of AMF for Y=0.91± 0.01
Should I implement X or Y?

Considerations:

1. If X is implemented I should expect a 10% reduction in accidents, if Y is implemented I should expect a 9% reduction in accidents. Since the costs are equal, X seems to be more cost-effective than Y

2. We are fairly sure that with Y we will get a 8%-10% reduction in expected accidents.
   However, with X we might get a change from a 20% reduction up to 10% increase range.

Reasoning:

Reminder of Example Choice:
Treatments X and Y have equal costs.
Estimate of AMF for X =0.9 ± 0.2
Estimate of AMF for Y=0.91± 0.01
Should I implement X or Y?

The guidance in the HSM will be used repeatedly and by many.

Number of sites	If treatment X preferred	If treatment Y preferred
200	30% reduction → 600	10% reduction → 200
600	10% reduction → 600	9% reduction → 540
200	10% **increase** → **-** 200	8% reduction → 160
1000 @ 10	**Expected Total Reduction 1000**	**Expected Total Reduction 900**

If Y is to be preferred to X one must argue that it is better to save fewer accidents overall in order to avoid the possible increase of expected accidents at some sites.

What might be the ethical principles behind such an argument?

Reasoning (cont.):

Six principles of medical ethics.

1. Beneficence - a practitioner should act in the best interest of the patient.
2. Non-maleficence - "first, do no harm".
3. Autonomy - the patient has the right to refuse or choose their treatment.
4. Justice - concerns the distribution of scarce health resources.
5. Dignity - the patient (and the person treating the patient) have the right to dignity.
6. Truthfulness and honesty - the patient should not be lied to.

1, 2, 4 and 6 seem relevant to road safety management.

Both X and Y pass the beneficence principle

X could be tripped up by the non-maleficence principle.

Reminder of Example Choice:
Treatments X and Y have equal costs.
Estimate of AMF for X =0.9 ± 0.2
Estimate of AMF for Y=0.91± 0.01
Should I implement X or Y?

The justice principle consists of two components.

- First, that there should be no discrimination in treatment decisions. That is all accidents of equal severity are to be valued the same, irrespective of where they occur or who might be involved.
- Second, that resources for treatment are not infinite.

These two components, jointly, mean that **it would be unjust** to prefer Y to X. (Were Y preferred to X we would end up saving fewer accidents for same $)

Reasoning (cont.):

My Opinion:
In road safety management the Justice Principle criterion should trump the Non-Maleficence Principle.
(Saving 2 while causing 1 is the same as saving 1 and better than saving and causing none)

This opinion, if shared by others, **implies**:

1. In choices such as that between whether to implement treatment X or Y, it is only the magnitude of the AMF estimate that matters, not its accuracy.

2. If the accuracy of the AMF estimate does not affect the choice of treatment, accuracy per se cannot convincingly serve for HSM inclusion-exclusion decisions.

3. Inclusion-exclusion guidance for the HSM must find a different foundation.

Reminder of Example Choice:
Treatments X and Y have equal costs.
Estimate of AMF for X =0.9 ± 0.2
Estimate of AMF for Y=0.91± 0.01
Should I implement X or Y?

Two Alternative Foundations:

1. **The "Publish All" Option**
2. The "Stability of Advice" Option

The "Publish All" Option:
All unbiased AMF estimates that are based on empirical evidence (i.e. information about crashes), irrespective of their accuracy, ought to be in the HSM and the HSM should be periodically updated.

+ the practice of road safety management would be best served if decisions were always based on the best evidence available at the time the decision needs to be made.

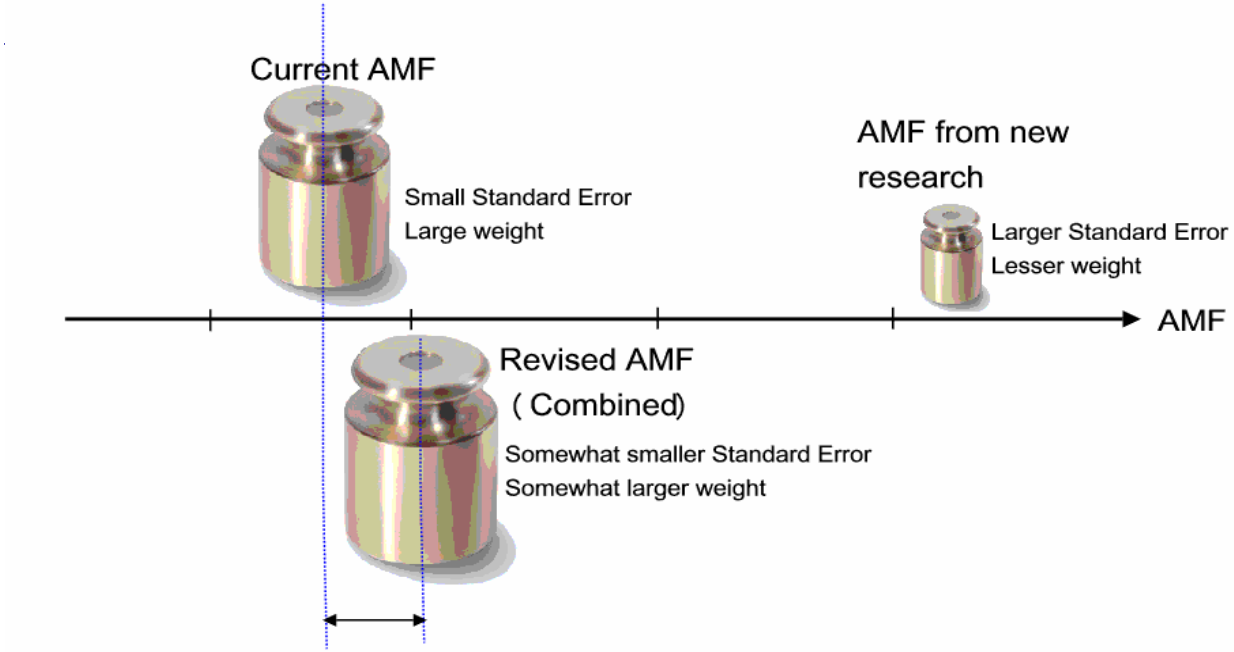
− Suppose that extant research indicates that on two-lane rural roads 11' lanes are safer than 12' lanes. If this was published in the HSM should highway agencies be pressed to reduce pavement width? Would they be sued if they did not? Would they be sued if the re-striped and it turned out that this caused an increase in accidents? What if some new research was done changing the AMF back in favour of 12 ' lanes and this was published in the next edition of the HSM? Would agencies now have to undo what the earlier edition of the HSM induced them to implement?

Two Alternative Foundations:

1. The "Publish All" Option
2. **The "Stability of Advice" Option**

Professional practice in transportation is characterized by temporal stability and consistency. While practice (and the associated standards, warrants, guidelines etc.) should change, such change ought to be deliberate and well justified. The inclusion of very inaccurately known AMF estimates in the HSM, estimates that might change drastically with the publication of new research results, would run counter to the stability trait of professional practice. **Option 2** is to argue that information in the HSM must be relatively stable over time. That is, that the information included in the HSM must be sufficiently sturdy so that new research conducted between one edition and another is unlikely to turn the previous information on its head. This can be cast into algebraic form.

How the current estimate of AMF changes when results of new research become available.

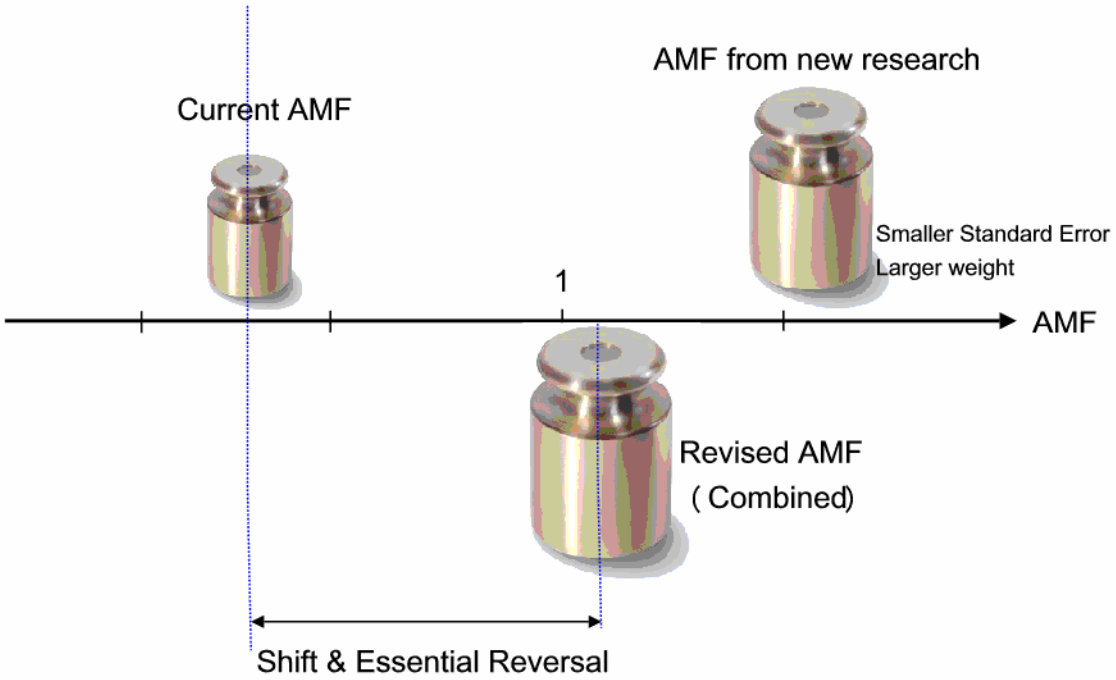


Example of a **stable** "Current AMF"

Principle:

- Combine "Current" and "New Research" AMF estimates to form the "Revised" AMF estimate.
- The weight of each estimate is proportional to $1/(\text{Standard Error})^2$

Ensuring Stability



Example of an **unstable** "Current AMF"

The main "Stability of Advice" rationale for the inclusion-exclusion decision:

Make sure that a reasonably accurate new research will not shift the current AMF estimate too far towards the AMF from new research.

(That is, the 'weight' of the current AMF must be sufficiently large or, equivalently, its standard error sufficiently small)

Ensuring Stability: Translating the Rationale into Algebra

The standard error of the current AMF must not exceed this value.

P* is the ratio:
Shift / (Distance between 'Current' and 'New Research' AMF estimates)

$$\sigma_C^* = \sigma_N^* \sqrt{\frac{P^*}{1 - P^*}}$$

THE STABILITY FILTER

This is the standard error of the AMF estimate produced by reasonably accurate future research

Example:
If we decide that $\sigma_N^*=0.1$ and $P^*=0.25$ then the standard error of all current AMFs in the HSM must be less than or equal to 0.06.

Ensuring Stability: Guarding against 'Essential Reversals'

There are two types of 'essential reversals':

Type A. The current AMF satisfies the stability filter but seems to be contrary to present practice

Type B. The current AMF satisfies the stability filter but is so close to 1 that an essential reversal is a possibility

For these two cases I recommend that a small committee of experts be constituted with the purpose of examining the AMFs in some detail. This committee should examine, among other things, the factual evidence on which the current AMF is based and also conduct an analysis to estimate the probability of the essential reversal to occur.

Break

Applying the Algebra

$$\sigma_C^* = \sigma_N^* \sqrt{\frac{P^*}{1 - P^*}}$$

- AMF stability will be determined from:
  - Standard error of current AMF: σ_C^*
  - Standard error of future new AMF (produced by reasonably accurate future research): σ_N^*
  - Acceptable difference between current AMF and future new AMF: P^*

Suggested Thresholds

$$\sigma_C^* = \sigma_N^* \sqrt{\frac{P^*}{1 - P^*}}$$

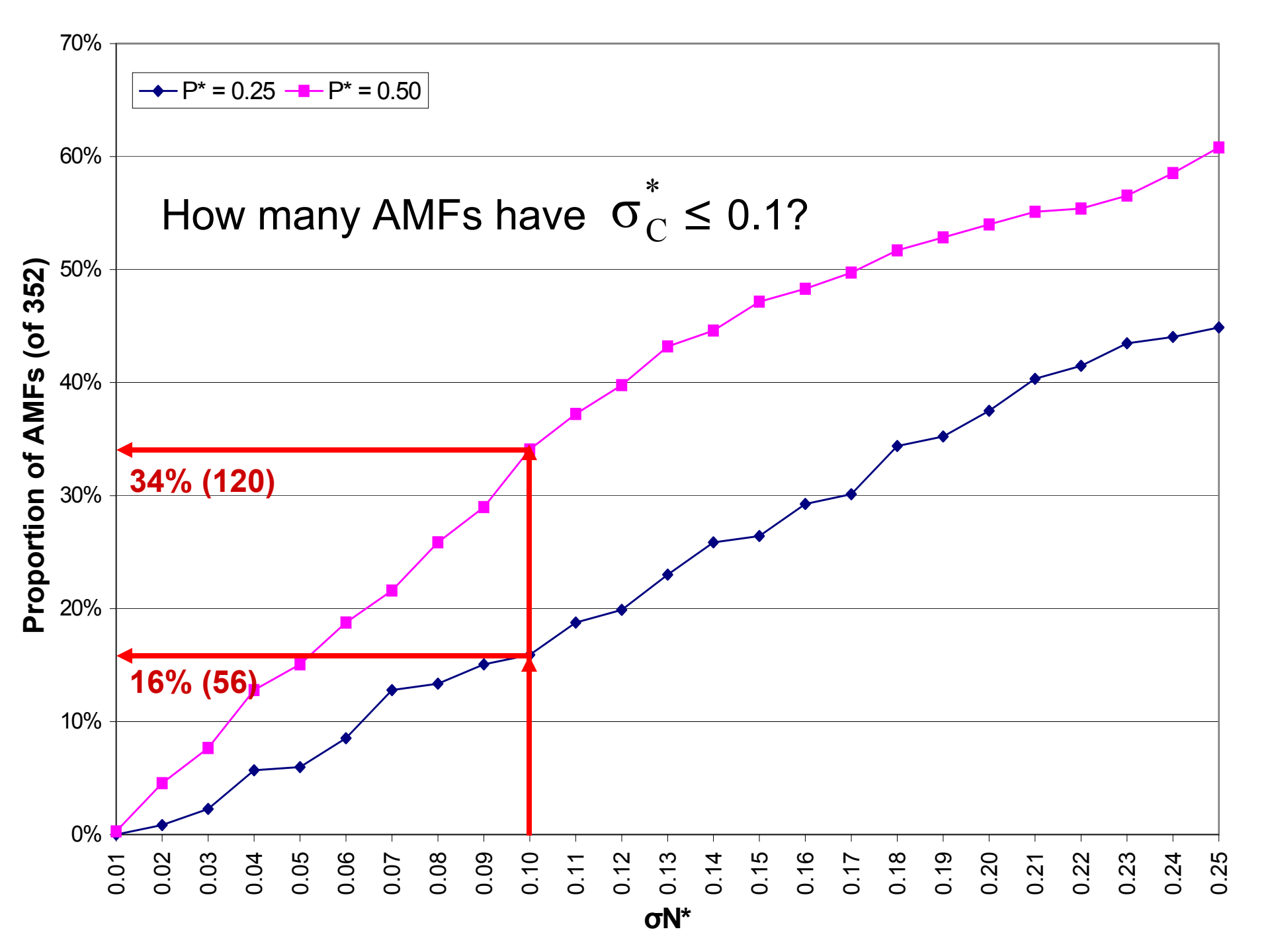
- P^* should not be larger than 0.5
  - Ensure that a revised AMF does not shift more than halfway from the current AMF to the future AMF
- σ_N^* should not be larger than 0.1
  - This accuracy is not easy to attain
- Thus, $\sigma_C^* \leq 0.1$

Preliminary Results

$$\sigma_C^* = \sigma_N^* \sqrt{\frac{P^*}{1 - P^*}}$$

Chapter	Treatments	AMFs
3	65	205
4	29	160
5	0	0
6	10	37
7	3	21
TOTAL	**107**	**423**

- AMFactors with std error = 352
- How many would pass varying "threshold" values of σ_N^* and P^* ?


P* = 0.25
P* = 0.50
How many AMFs have $\sigma_C^* \leq 0.1$?
34% (120)
16% (56)
Proportion of AMFs (of 352)
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.10
0.11
0.12
0.13
0.14
0.15
0.16
0.17
0.18
0.19
0.20
0.21
0.22
0.23
0.24
0.25
σN*

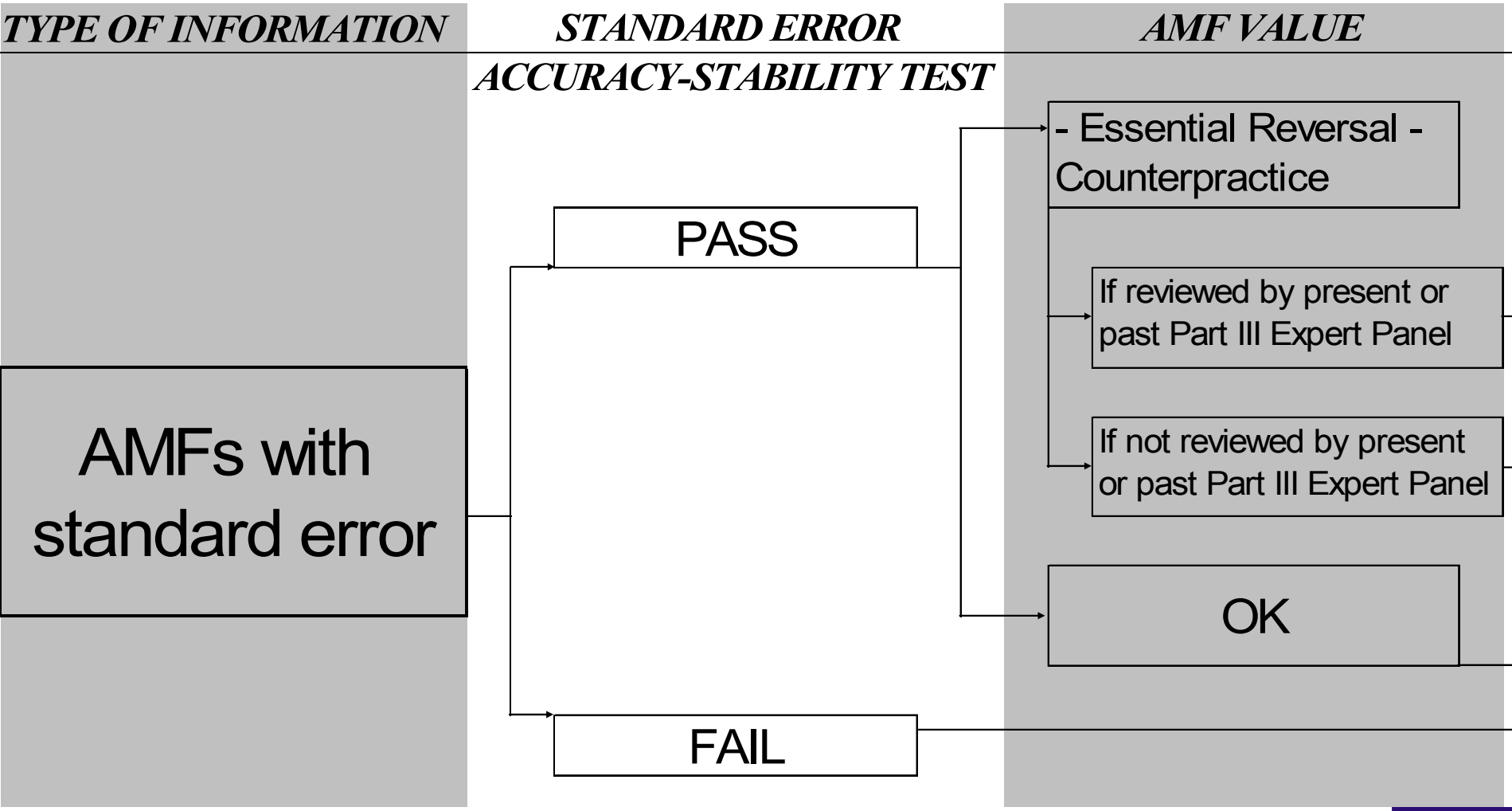
"Essential Reversal"

- AMF satisfies stability but may be contrary to present practice
- AMF satisfies stability but is so close to 1 that an essential reversal is a possibility: $0.9 \leq AMF \leq 1.1$
  - 33 of 120 AMFs that pass $\sigma_C^* \leq 0.1$ are within Essential Reversal range

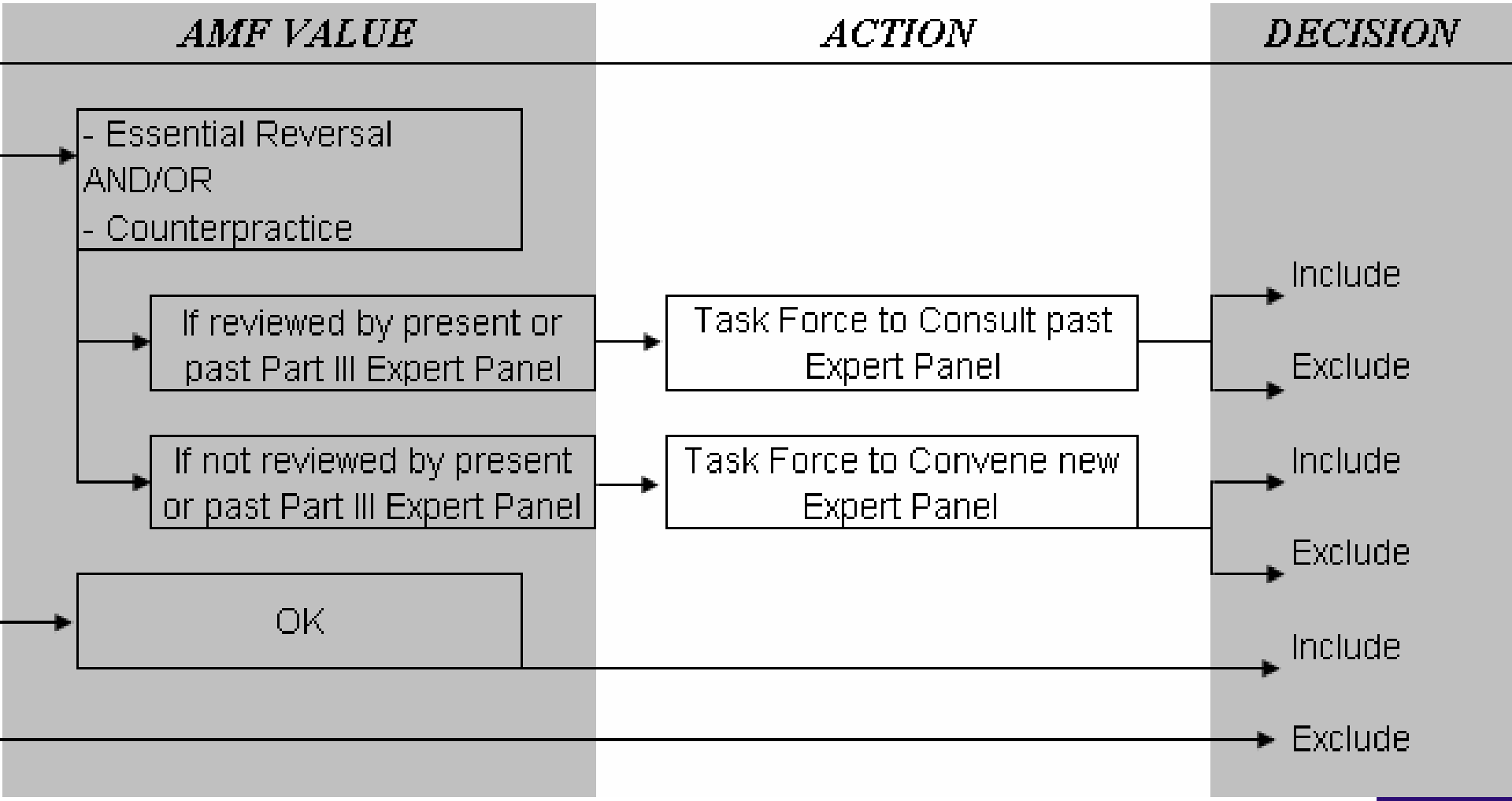
Decision Rule Process

- Interim Report "Knowledge-Base":
  - AMFs (with standard errors)
  - AMFs (without standard errors)
  - AMFs (with and without standard errors) that perhaps run counter to present practice
  - Non-crash based effects of treatments (measured by surrogate measures)
  - Anecdotal crash-based effects of treatments

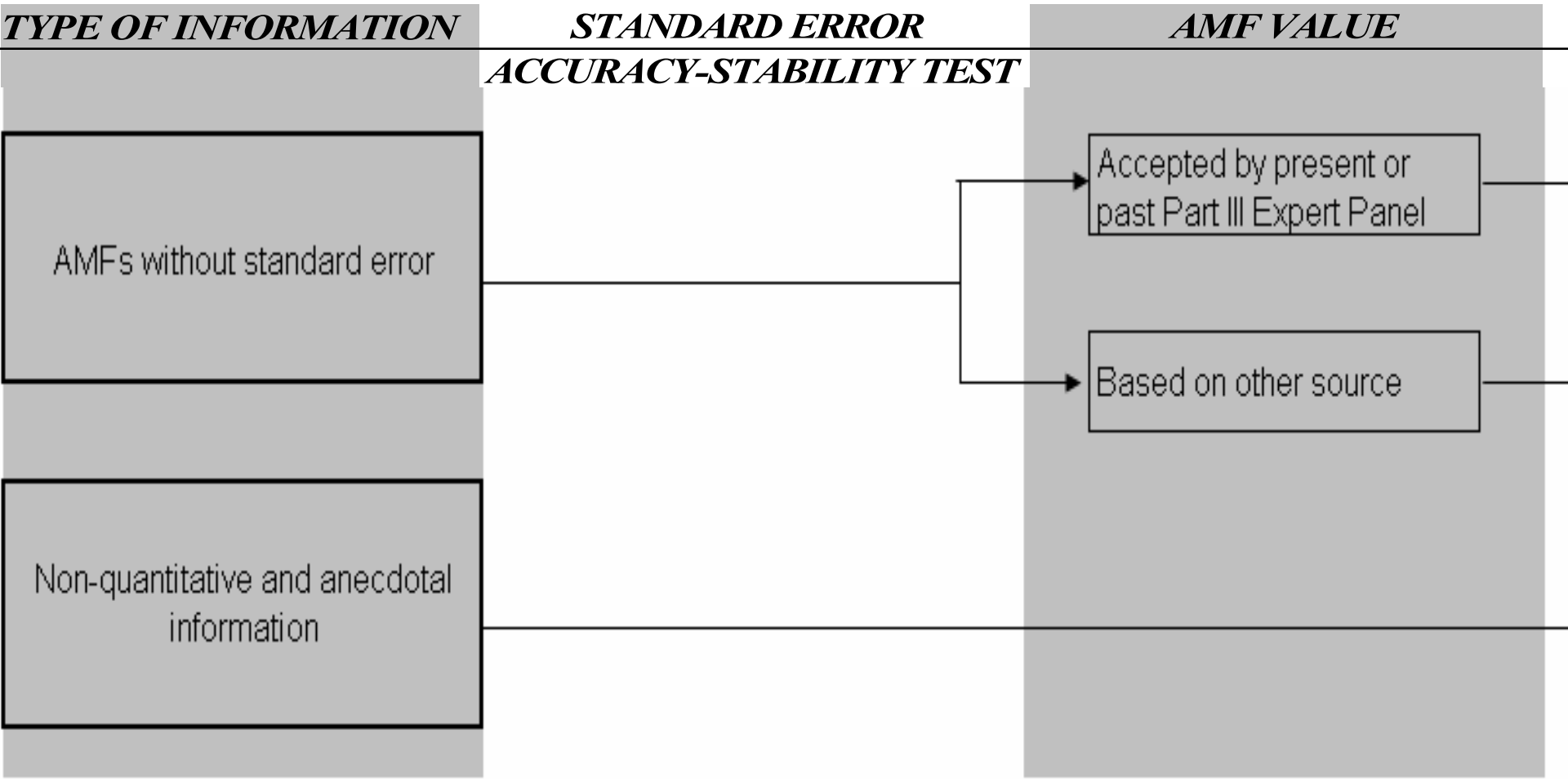
Decision Rule Process



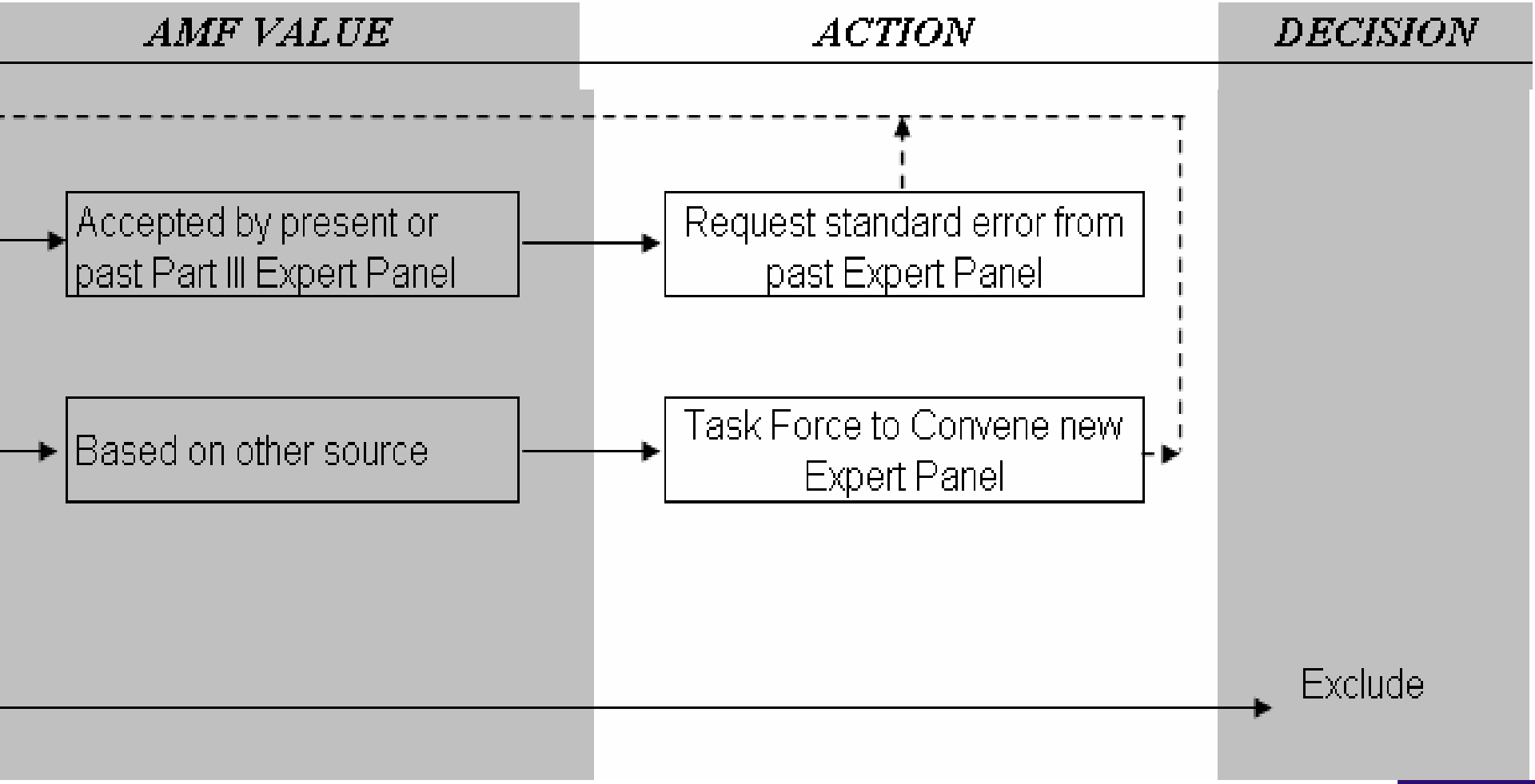
Decision Rule Process



Decision Rule Process



Decision Rule Process



Future of the Knowledge base

- Concern that if all knowledge compiled for Interim Report is not published, it will be lost
- Suggest "custodian" be identified to:
  - Host knowledge base (web); available to HSM users
  - Update and expand knowledge base
- We would continue to develop the knowledge base given funding

Potential Outcomes

1. Adoption by HSM Task Force and approval by Panel to proceed with Task 9: Part II Prototype Chapter
   - Extension of 12 months from original schedule
2. Additional research required before proceeding with Task 9
   - Unknown schedule

THANK YOU

Questions?